SPECIFICATIONS

FOR

TWO DIRECT-ACTING COMPOUND

TWIN-SCREW BEAM ENGINES

OF 5,000 HORSE-POWER,

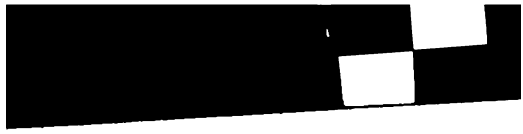
FOR THE

U. S. STEAMER CHICAGO;

INCLUDING

BOILERS, AIR AND CIRCULATING-PUMPS, BLOWERS, AND ENGINES, AND ALL THE APPENDAGES AND APPURTENANCES COMPLETE, TOGETHER WITH A LIST OF THE DUPLICATE PIECES, OIL-TANKS, INSTRUMENTS, AND TOOLS TO BE FURNISHED.

WASHINGTON
GOVERNMENT PRINTING OFFICE.
1883.



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TWIN-SCREW BEAM ENGINES

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GENERAL DESCRIPTION OF MACHINERY.

Each engine with its auxiliary machinery will be placed in a separate water-tight compartment, one forward of the other. There is to be one high and one low-pressure cylinder for each engine; they will be located side by side, with their axes vertical and 8 feet apart. The center lines of crank-shafts and high and low-pressure cylinders will be respectively 5 feet, 1 foot 5 inches, and 1 foot 8 inches from the center line of ship; the cylinders of forward engine will be placed on port side. The diameters of the cylinders will be 45 and 78 inches, and the piston strokes 52 and 54 inches. The cylinders will be steam jacketed and provided with slide steam-valves, the cut-off valves to be adjustable between the limits of $\frac{1}{8}$ and $\frac{5}{8}$ of the stroke of the piston while the engines are in motion. The main valves are to be worked by means of eccentrics and links through arms and rock-shafts; the cut-off valves will receive their motion from the beam centers. The exhaust steam from the high-pressure cylinder will pass directly to the low-pressure steam-chests; it will also be arranged with suitable pipes to exhaust the steam into the condenser and the atmosphere. The low-pressure cylinders will be fitted to receive the steam direct from the boilers, and also to exhaust

into the atmosphere. The condensers are to be placed on the outboard sides of the low-pressure cylinders and will each have a cooling surface of 4,960 square feet. There is to be an independent, combined, double-acting air and circulating-pump for each engine; they will be located near the outboard side of condensers.

The beam pillow-blocks will rest upon the cylinders and the frames connecting the crank-shaft blocks. The beams for each engine will be constructed of two steel plates of parabolic form, and with skeleton-frames if required.

The crank-shafts for each engine will be made of steel, in two separate interchangeable sections, and secured to each other and to the line-shaftings by couplings forged on the shafts. The cranks will have a length of 2 feet and be placed at an angle of 90° with each other.

The reversing cylinders will be located between the cylinders and crank-shafts, and will connect directly with the arms of the rock-shafts; the valves to be operated by floating levers on the working platform.

The line-shaftings will be made of steel; they are to be placed parallel with and 9 feet from the center line of the ship. The screw-propellers will be made of steel, 15 feet 6 inches in diameter, and about 22 feet 6 inches pitch, each with four adjustable blades, or of such design as may be approved to obtain best results.

There are to be placed in each engine-room one of Blake's horizontal steam-pumps, having a water-piston of 16 inches diameter and 14 inches stroke; the after pump to be connected with the water-tight compartments abaft the bulkhead of forward engine-room, the forward pumps to be connected with the water-tight compartments in forward engine-room and after boiler-room. There is also to be a compartment-pump of the same capacity in the forward fire-room, to connect with it and the water-tight compartments forward of it. There are to be two Blake pumps, having water-pistons of 7 inches diameter and 12 inches stroke, located in the after fire-room; the pumps to be connected with the sea-valves, and fitted with the requisite pipes and valves for feeding, washing out, and pumping out the boilers, and for fire purposes.

There will be a special pump for the fresh-water distiller.

There is to be an auxiliary surface condenser, into which all the heaters, pumps, blowers, windlass and steering-engines will exhaust, and one of the large compartment pumps will circulate the water through it.

There are to be fourteen cylindrical steel-boilers with rectangular water-legs in the rear of back connections; the shell of boilers to be 9 feet in diameter; the total length to be 9 feet 10 inches. The boilers will be arranged in two water-tight compartments, with a fire-room 11 feet wide fore and aft between them. The after compartment will contain eight and the forward compartment six boilers. The boilers are to have a total heating surface of 18,500 square feet. The grates will be placed beneath the shells of the boilers, the total surface to be 802 square feet. The boilers will rest on wrought-iron pedestals inclosed with fire-brick extending to the back water-legs, the boilers to be arranged for forced combustion, and the fire-rooms constructed to maintain a pressure of air due to a column of $1\frac{1}{2}$ inch of water.

There are to be two blowers in each fire-room; those in the after room to be capable of discharging 20,000 cubic feet of air per minute, the others 15,000 cubic feet of air per minute. They will receive the air from outside, through ducts provided for them.

DETAILED DESCRIPTION OF ENGINES, SHAFTING, SCREW PROPELLERS, BOILERS, PUMPS, &c.

CYLINDERS AND CASINGS.

The cylinder casings, which will include the steam and exhaust ports, passages, lower-heads, and sole-plates, flanges for cylinder-covers, valve-chests, beam pillow-blocks, &c., are to be of the best cast iron. The casings for high-pressure cylinders are to be 51 inches in inside diameter and $1\frac{3}{8}$ inch thick; those for the low-pressure cylinders are to be 84 inches in inside diameter and $1\frac{1}{2}$ inch thick; they will be fitted with linings which will inclose an annular space of $1\frac{1}{2}$ inch, and a packing space at the upper ends of $1\frac{1}{2}$ by 8 inches deep.

LININGS.

The linings to be of the best iron, cast as hard as can be worked; they will be $1\frac{1}{2}$ inch thick, and made with flanges 2 inches thick, and will be turned, faced, and accurately fitted to the casings as shown in the drawings. They will be smoothly bored to their respective diameters of 45 and 78 inches.

CYLINDER-HEADS.

The cylinder-heads are to be made with double shell $1\frac{1}{4}$ inch thick, and amply stiffened by ribs 1 inch thick; each will have a man-hole cored in, bored and faced to receive the man-hole plate.

CYLINDER-COVERS.

The covers are to be of the best cast iron with double shells $1\frac{1}{4}$ inch thick, and well stiffened by ribs 1 inch thick; they will have faced flanges 5 inches wide and $2\frac{1}{4}$ inches thick; the covers to be finished on the outside; they will

be secured in place and to flanges 2⅜ inches thick by bolts 1½ inch in diameter with finished nuts. They will have man-holes 15 inches in diameter and closed with double shell plates finished on the outside.

STEAM AND EXHAUST-PORTS.

The steam and exhaust-ports are to be double and in two divisions; those for the high-pressure cylinders are to be 1¾ inch wide and 22 inches long; those for the low-pressure cylinders are to be 1⅞ inch wide and 35 inches long.

The high-pressure cylinder exhaust passages will each have two openings of 10½ inches diameter, and they will be covered by copper pipes, which will connect with the low-pressure steam-chests Each low-pressure cylinder will exhaust through passages leading on each side to the rear and top of the casings, and will terminate in openings 13 inches in diameter, with faced flanges 5 inches wide. Each cylinder is to be provided with ports for starting-valves, which are to be not less that 9 inches in area.

The cylinders are to have a port at each end, of not less than 15 inches area for relief-valves. They will have sole-plates 2½ inches thick, well ribbed to the lower heads and casings, and substantially secured to the keelsons by bolts 2¼ inches in diameter.

Any change in the valve gear or any other details that may appear advisable, may be made provided the same does not alter the general design, and is approved by the Naval Advisory Board.

VALVE-SEATS.

The valve-seats are to be of cast iron of the very best quality and as hard as can be worked; they are to be 1½ inch thick, and secured in place with composition countersunk screws ⅞ inch in diameter.

VALVE-CHESTS.

The valve-chests are to be of cast iron with walls 1¼ inch thick, and faced flanges 2 inches thick and 4½ inches wide; all to be well ribbed and constructed to support and sus-

tain the parts of beam pillow-blocks that rest upon them; they will also have upon their bases pillow-blocks cast on them for the reversing-shaft bearings.

VALVE-CHEST COVERS.

The chest covers to be made of the best iron cast with double shell 1 inch thick, well ribbed, and finished on the outside except in the panels; the flanges to be 2 inches thick and 4½ inches wide. The covers to be secured in place with bolts 1⅜ inch in diameter, spaced not over 6 inches apart.

MAIN SLIDE-VALVES.

There are to be two main slide-valves for each cylinder, each to be double-ported, those for the high-pressure cylinders to have ports 1½ inch wide and 22 inches long, the valves to have a throw of 2 inches; the valves for the low-pressure cylinders to have ports 1¼ inch wide and 35 inches long, and a throw of 22 inches. The valves to be fitted with steam cylinders open to the chests, and having pistons of such area that they will balance the weight of the valves. There will also be provision for relieving the pressure upon the valves, if required.

CUT-OFF VALVES.

The cut-off valves are to work on the backs of the main valves; they are to be of cast iron, ⅝ inch thick, well ribbed, and will each have a throw to correspond with its main valve.

VALVE-STEMS.

The valve-stems are to be of steel; those for the main valves to be 3 inches in diameter, the cut-off stems to be 2¼ inches in diameter. They will be secured with composition nuts accurately fitted in the pockets of the valves, and connected by links to the arms of the rock-shafts. The cut-off stems to be made with right and left handed screws to work in the nuts of valves and otherwise fitted for adjusting the valves while the engines are in motion.

VALVE-STEM STUFFING-BOXES.

The stuffing-boxes are to be of composition; each will have an annular packing-space of $\frac{5}{8}$ inch and 8 inches deep. They are to be fitted with packing of approved kind, and will have screw-followers, adjustable by worm-screws, with handles accessible while the engines are in motion.

MAIN PISTONS.

Each piston is to be made of composition; the shell and ribs are to be $\frac{1}{2}$ inch thick, the rims to be $\frac{7}{8}$ inch thick, and the metal around the eyes of piston-rods to be $2\frac{1}{2}$ inches thick. The pistons will be fitted with cast-iron packing-rings 3 inches wide and $\frac{1}{2}$ inch thick, and an inner ring 6 inches wide and $\frac{5}{8}$ inch thick, all adjusted by steel springs of the proper tension. The followers are to be $1\frac{3}{4}$ inch thick, secured in place with wrought-iron bolts $1\frac{1}{2}$ inch in diameter placed not over 12 inches apart.

PISTON-RODS.

The piston-rods are to be of steel, finished $7\frac{3}{4}$ inches in diameter; they will each be made with a conical head accurately fitted in the pistons and secured by a composition collar-nut recessed 1 inch into the piston. Each rod will also be secured to a cross-head by composition collar-nuts recessed $1\frac{1}{2}$ inch.

PISTON-ROD STUFFING-BOXES.

The stuffing-boxes are to be of composition, each fitted with a gland and follower; they will have an annular packing-space of 1 inch and — inches deep; they will have flanges 1 inch thick and 3 inches wide, well secured in place with bolts 1 inch in diameter; they will be fitted with packing of approved kind, and the followers adjusted by worm-screws with handles accessible while the engines are in motion.

CROSS-HEADS AND GIBS.

The cross-heads are to be made of steel, each with a central cubical boss 15 inches in diameter and 14 inches

deep, with journals 7 inches in diameter and 7 inches long on each side, for the connecting links; the journals will have shoulders 11 inches in diameter on the boss, and collars 9 inches in diameter, from which the arms of the cross-heads will taper to a diameter of 6 inches and terminate in palms 8 inches long, 6 inches wide, and 3 inches thick for the gibs. The bosses will be bored and counter bored for the piston-rods and nuts, the latter to be secured by steel set-screws. The gibs will be of composition and will have a wearing-face 6 inches wide by 12 long.

CROSS-HEAD GUIDE-FRAMES.

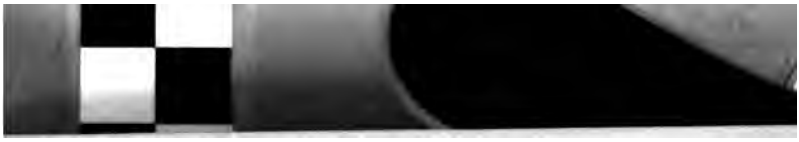
The cross-head guide-frames are to be made of cast iron, well ribbed and secured to each other and to brackets on the high-pressure cylinders and to the covers of the low-pressure cylinders; they will also be stayed by brace-rods secured to beam pillow-block frames.

CONNECTING-LINKS.

The connecting-links will be made of steel, and 24 inches long between centers; they are to be 5½ inches wide and 3 inches thick, or with a total cross section of 33 inches; they will each be fitted with brasses 1½ inch thick, for the cross-head and beam-pin journals, which are to be adjusted by double gibs and a single key, secured by steel set-screws.

BEAMS.

The beams are to be constructed of two cast-steel plates of parabolic form, 10 feet 9⅞ inches long between extreme centers for high-pressure cylinder, and 11 feet 1 inch for low-pressure cylinder; from center of beams to center of connecting-rod pins, 5 feet 2⅜ inches; greatest depth of beam, 48 inches; the web of the plates will be 1½ inch thick, with a perimeter 3 inches wide and 2 inches thick; the bosses for the beam-centers to be 20 inches in diameter and 12 inches thick; those for the connecting-rods to be 15 inches in diameter and 7 inches thick, and those for the connecting-link pins to be of the same diameter and 8½ inches thick. All the



pins will be made of steel and accurately fitted and keyed in place; the beam-centers to have journals 10 inches in diameter and 21 inches long, those for the connecting-rods to be 8 inches in diameter and 13 inches long, and the pins for the links to be 7 inches in diameter and 7 inches long. The castings for the beams are to have a tensile strength of 75,000 pounds per square inch; if not attainable of the strength required, the beams are to be constructed of forged or rolled steel plates of that strength, with the bosses welded on, or they may be made with skeleton-frames, if required.

CONNECTING-RODS.

The connecting-rods are to be made of steel and fitted with straps, gibs, and keys, the latter well secured by steel set-screws; they will be 9 feet long between centers, $7\frac{3}{4}$ inches and $8\frac{1}{4}$ inches in diameters of necks, and $9\frac{1}{4}$ inches in diameter at center; they will be fitted with brasses accurately bored and scraped to suit the journals.

CRANK-SHAFTS.

The crank-shafts are each to be made in two interchangeable sections; each section is to be constructed of steel, forged solid, with oval crank-webs 7 inches in thickness and 24 inches in greatest width. The main journals are to be 13 inches in diameter and 22 inches long; the crank-pin journals to be 12 inches in diameter and 20 inches long; the shoulders of main journals to be 18 inches in diameter. Each shaft will have a coupling 26 inches in diameter and 5 inches thick, forged on each end; the two sections of each shaft will be secured together by four steel key-bolts 2 inches by 2 inches wide, and a steel cross-key 2 inches thick and 3 inches wide between the couplings.

CRANK-SHAFT BRASSES.

The brasses are to be in two parts for each journal, divided in a vertical plane; they are to be cast hollow and

fitted for the circulation of water through them, and provided with the necessary pipes and valves. The metal around the bearing faces to be 1½ inch thick, the shells and ribs to be ¾ inch thick; the brasses are to have faced flanges 1½ inch thick, which terminate in collars 18 inches in diameter to match the shoulders of the journals.

CRANK-SHAFT PILLOW-BLOCKS.

The pillow-blocks are to be made of cast steel, faced 16 inches wide and fitted with chocks and liners for the brasses. The base of each block will be cast hollow, the walls to be 1½ inch thick, the sole-plates to be 3 inches thick and 16 inches wide, well ribbed to the walls; the blocks to be secured to the keelsons, each by two steel bolts 4½ inches in diameter. The caps are to be of wrought iron 2½ inches thick, each formed with two lugs 2 inches wide, extending across the caps and projecting 2 inches, to lock over the jaws of the blocks; the caps will be secured in place by steel bolts 4½ inches in diameter, with finished nuts.

BEAM PILLOW-BLOCKS AND FRAMES.

The beam pillow-blocks and the frames upon which they rest will also be constructed of cast steel, the body of frames to be 16 inches wide and 1½ inch thick, the side flanges 18 inches wide and 1½ inch thick; the frames will be made in two parts, divided on the center line of cylinders; they will be firmly secured together, each with four steel bolts 2 inches in diameter, through flanges 2¼ inches thick; they will be keyed and firmly bolted to each crank-shaft block with four bolts 2 inches in diameter, and also to the keelsons by two bolts 4½ inches in diameter, passing through sole-plates 3 inches thick.

The pillow-blocks are to be faced 17 inches wide for the beam-center brasses, which will rest in beds between jaws fitted with chocks and liners, and covered with wrought-iron caps 4 inches thick, with lugs locking over the jaws and secured in place each with two steel bolts 4½ inches in diameter, with finished nuts. The main web of the blocks

will be 1 inch thick, and will be bounded by flanges 16 inches wide and 1¼ inch thick, terminating in legs with sole-plates 2½ inches thick and 16 by 18 inches wide. The blocks will combine in them the bearings for the rock-shafts for the main and cut-off valves, and will be faced 16½ inches wide for the former, which will be fitted with wrought-iron caps secured each by four steel bolts 2¼ inches in diameter, with finished nuts. The caps for the cut-off bearings are to be of wrought-iron, 6 inches wide, secured each by two steel bolts 2 inches in diameter. The blocks will be secured to the cylinders and pillow-block frames by steel bolts 3 inches in diameter, four of them to be in each sole-plate.

BRASSES.

The brasses for the beam-centers will be 2 inches thick and 21 inches long, with collars filleted to match the shoulders and collars of the centers. Those for the main valve rock-shaft are to be 1½ inch thick, the brasses for cut-off shafts to be 1 inch thick. All to be bored and faced to match the journals and shoulders.

VALVES, ROCK-SHAFTS, AND CONNECTIONS.

The main valve rock-shafts are to be of steel 8½ inches in diameter, fitted with journals 19 inches long. Each valve-stem will be connected directly with an arm on the rock-shafts by two links coupled to them by two composition rings fitting concentric grooves in each end of the links and the connecting bosses, each couple to be clamped and adjusted by a steel bolt 1¼ inch in diameter, with finished nuts and steel set-screws.

The valve and link arms are to be of wrought iron of ample strength and in good proportion.

ECCENTRICS.

The eccentrics are to be made of cast steel in two parts, and each finished to a diameter of 40 inches and a face of 4½ inches, and to have a throw of 2½ inches; they will be rab-

beted 2½ inches wide and 1 inch deep on each side at circumference, for the flanges of straps. They will be clamped on the couplings of the crank-shaft, each by two malleable-steel bolts 1¾ inch in diameter, and also secured in place by the coupling key-bolts already referred to.

ECCENTRIC-STRAPS.

The straps are to be of composition, in two parts, finished all over; they will be 2 inches thick, and made with flanges to match the rabbets of the eccentrics, and with lugs for the link-bars and the clamping-bolts; they will be secured together by two malleable-steel tap-bolts 2¼ inches in diammeter, with finished heads.

ECCENTRIC BARS.

The eccentric bars are to be of the best wrought iron recessed into and fixed to the lugs of straps by three wrought-iron tap-bolts with finished heads; section of metal of strap at lug to be 2½ inches by 4 inches; the bars are to be forked and coupled to the links by straps, gibs, keys, and brasses of the proper proportions; the length from center of eccentric to center of link to be 72 inches.

LINKS.

The links are to be of wrought iron, made with two bars 2 inches thick and 6 inches wide, secured together with 1½-inch stud-bolts at each end, with thimbles 2¾ inches in diameter. The pins for the eccentric-bars are to be forged on, and finished to 3½ inches in diameter and 2¾ inches long, and to be 23 inches between centers.

LINK-BLOCKS.

Each link-block will be of wrought iron, with pin forged in and finished to a diameter of 3½ inches and a length of 3 inches; the jaws will have lips 10 inches long, projecting 2 inches; they will inclose adjustable composition gibs 12 inches long; each block will have a movement of 23 inches.

SUSPENDING-RODS FOR MAIN LINKS.

The suspending-rods are to be of wrought iron, and forked to connect with both sides of the links; they will couple with the links by means of composition rings fitting concentric grooves in the bosses of the rods and links, and adjusted to links each by a wrought-iron bolt 1½ inch in diameter with washer and nut; the rods will be connected to rock-shaft arms in the same manner as to the links.

VIBRATING BEAM.

A vibrating beam will couple the link-block with the rock-shaft arm-pin and a radius-bar; it is to be formed of two straps of wrought iron and two sets of well-proportioned gibs, keys, and brasses; the straps to be 3 inches wide and 2¼ inches thick; the beams for working the valves to be 15½ inches between centers of block and arm-pin, and 35½ inches between extreme centers of pins.

RADIUS-BARS.

The radius-bars are to be made of wrought iron 6½ inches between centers for high-pressure cylinder and — inches between centers for low-pressure cylinders; the pins are to be 2¼ inches in diameter and 3 inches long; the journals to be 3 inches in diameter and — inches long. The bearings are to be fitted with brasses adjustable to the journals.

REVERSING-SHAFT AND ARMS, SUSPENDING-LINKS, &C.

The reversing-shafts are to be of steel 5½ inches in diameter, each made in two sections, and coupled together by the boss of a central arm to which they will be keyed fast. The shafts will have two journals, 12 inches long on each section, and fitted with brasses which rest in bearings beneath the valve-chests. The arms and suspending-links are to be of wrought iron and in good proportion to the other work.

REVERSING-ENGINES.

The reversing-engines are each to have a single cylinder of 18 inches diameter; the piston stroke to be 22 inches. They will connect directly with the central arms on rock-shafts, and be worked by means of floating-levers which connect with valves, covering ports each having an area of 2 inches.

ENGINE-ROOM.

All the levers, handles, &c., for operating the starting-valves, throttles, relief-valves, reversing-engines, &c., are to be located on working platforms outboard of the crank-shafts and near them. There will be means of approach to all moving parts, arranged with proper ladders and steps, fitted wherever necessary with brass hand-rods supported by wrought-iron columns.

INDICATORS.

The indicators are to be placed on the cylinders in a suitable and accessible position, and they, as well as the counters, are to be operated by levers, not pulleys.

GOVERNORS.

A marine governor of approved design and sufficient power is to be attached to each engine.

CONDENSER CHESTS AND TUBES.

The condensers are to be placed at the outboard side of the low-pressure cylinders, and to rest upon them and the frames of the air and circulating-pumps. The chests are to be of cast iron, well ribbed throughout; the body of the chest and the ribs will be 1 inch thick, the flanges for the tube-sheets and bonnets and delivery-pipes $1\frac{5}{8}$ inch thick; the exhaust-nozzles will be 13 inches in diameter, and will have faced flanges 4 inches wide and $2\frac{1}{4}$ inches thick, which are to cover corresponding openings in low-pressure

cylinder-casings, to which they will be substantially bolted, so that the joints shall be perfectly air-tight; the induction and discharge nozzles for the circulating water are to have an area of 113 inches; the channel-ways to air-pumps are each to have the same area.

TUBES.

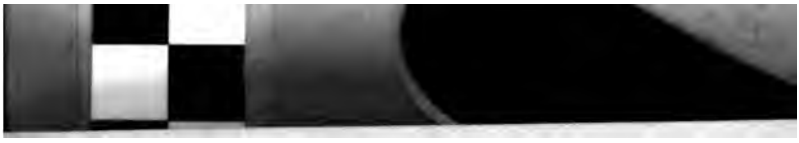
Each chest will contain 3,708 drawn-brass tubes $\frac{5}{8}$ inch in outside diameter, of No. 18 wire-gauge thickness, and 112½ inches long; the exposed condensing length to be 109½ inches, and cooling surface 4,960 square feet. The tubes for each condenser will be placed fore and aft, and arranged in two divisions, so that the condensing water will pass to the outboard-delivery valve through the tubes of each division; all the tubes to be thoroughly tinned inside and out.

TUBE-PLATES.

The tube-plates are to be of cast iron 1¼ inch thick, bored for the tubes and counterbored $\frac{7}{8}$ inch in diameter and 1 inch deep for wooden or paper grommets, as may be approved; the tubes to be placed 1 inch between centers, the tube-plates to be secured to faced flanges 2½ inches wide, by composition bolts 1¼ inch in diameter, placed not over 5½ inches apart. Each division of tubes will be sustained by a brass supporting-plate $\frac{3}{4}$ inch thick, placed equidistant between tube-plates. The water-chambers are to be closed with bonnets, having faced flanges 3½ inches wide, and recessed panels; each bonnet to have a man-hole 16 by 25$\frac{5}{8}$ inches, closed by a cover with faced flanges 3 inches wide.

AIR AND CIRCULATING-PUMPS.

Each engine will have one of Blake's independent double-acting combined air and circulating-pumps placed beside the condenser and constructed with the necessary channel-ways to connect with and support it. Each pump and each cylinder will be 24 inches in diameter and 24 inches stroke.



Two double-acting feed-pumps 5 inches in diameter will be worked from a cross-head on the piston-rod of each pump, and arranged to draw the water from a hot-well above the delivery-valves of air-pumps or from the fresh-water hot-well of the filter; the circulating-pumps will connect with the main injection by copper pipes 12 inches in diameter; the outboard-delivery pipes will also be of copper 12 inches in diameter. All the pipes to be thoroughly tinned inside and out.

BILGE-PUMPS.

There are to be two bilge-pumps, with a capacity of 100 gallons per minute, and worked from the beams of engines. Each pump is to be fitted with receiving-pipes of cast iron; the discharge to be connected to main outboard-delivery valve-chamber, or a special discharge-valve, by copper pipes.

All bilge receiving-pipes to be fitted with Macomb strainers, in easily accessible positions.

AUXILIARY PUMPS.

There are to be two horizontal steam-pumps, having water-pistons 7 inches in diameter, with a stroke of 12 inches, or of equivalent capacity; they are to be right or left, according to position, placed one in each fire-room, and fitted for feeding and pumping out the boilers, as bilge-pumps and for fire-apparatus. There is to be a pump of the same size fitted especially for the distiller. There are also to be three horizontal steam-pumps of the same pattern, having water-pistons 16 inches in diameter and 14 inches stroke, or of equivalent capacity, fitted for fire-engines and bilge-pumps; one will be in each engine-room and the other in the forward fire-room, and fitted to pump from the several water-tight compartments as above described.

A steam-pump of sufficient capacity is to be supplied, which shall furnish a constant head of water in the seamen's water-closets, and to other water-closets, bath-rooms, and wash-places if required.

AUXILIARY CONDENSER.

All the heaters, pumps, blower engines, steering and other small engines are to be arranged to exhaust into the atmosphere, and also into an auxiliary condenser. The condenser is to be placed above the filters, into which it will drain, and one of the pumps last mentioned is to circulate water through it.

FEED-WATER FILTERS.

There are to be two filters, which will receive the drain from the main cylinders and jackets, steam-pipes, the discharge from air-pumps, safety-feed valves, &c., and from the auxiliary condenser aforesaid. Each will have a capacity of not less than 500 gallons, and will discharge into a separate fresh-water hot-well, connected by suitable valves to the receiving side of the feed-pumps, and fitted with a salt-water supply, so placed that the water admitted will pass through the filter, and the quantity can be seen and measured. The hot-wells will be arranged so that the deficiency of feed-water may be supplied from the distilling apparatus.

INJECTION-VALVES.

The two main injection-valves will also be placed on each side of the ship between frames 52 and 53, and 54 and 55.

The valve-chambers are to be of cast iron, and the seats, stems, stuffing-boxes, and valves of composition, the latter to cover openings 12 inches in diameter, and faced with gum and fitted with screw-valve stems turning independently of the valves. There will be a nozzle 4 inches in diameter for fire-pump suction on the stand-pipe of chamber below the valve.

There will be strainers covering the openings through the ship's side, and perforated with $\frac{5}{8}$-inch holes, equivalent to twice the area of the injection-pipes.

OUTBOARD-DELIVERY VALVES.

The two outboard-delivery valves are to be placed on each side of the ship, between frames 52 and 53, and 54 and 55.

The valve-chambers will be of cast iron, and the seats, stems, stuffing-boxes, valves, &c., of composition; the latter to have rubber faces, to cover openings 12 inches in diameter, and fitted to operate as checks.

The chambers are to be fitted with nozzles 4 inches in diameter for the discharge from the bilge-pumps, and are to be substantially secured over openings 12 inches in diameter through the side of the ship.

BILGE INJECTIONS.

Bilge injections 8 inches in diameter will be connected with the main injection-pipes, and furnished with ample strainers, easily accessible for cleaning and inspection.

SEA-VALVES FOR PUMPS.

There are to be two receiving and discharge valves for auxiliary pumps; one on each side of the ship opposite the blow-valves, and the same distance from the center line of the ship.

The chests are to be of cast iron, each with three branch nozzles – inches in internal diameter, and fitted with composition valves and seats.

The valves are to be 6 inches in diameter, and fitted with brass screw-stems, stuffing-boxes, and hand-wheels,and connected to the pumps by copper pipes.

The receiving-valve chambers are to have external strainers with $\frac{3}{8}$-inch holes, equivalent in area to twice that of the valves.

Each pump will also be provided with a bilge-receiving valve – inches in diameter.

BOILER SEA-VALVES.

The chests of the two boiler blow-valves are to be of cast iron, each with three branch nozzles 4 inches in diameter of openings; they are to be fitted with composition valves and seats.

The valves are to be 6 inches in diameter, and fitted with brass screw-stems, stuffing-boxes, and hand-wheels. The

chests are to be attached to the ship in the same manner as those of the main injection-valves.

They are to be placed opposite the sea-valves for pumps, between frames 28 and 29, and 40 and 41, and 5 feet from the center line of vessel.

LINE-SHAFTING.

The line-shafting for each engine will be made of steel in four sections, and finished 13 inches in diameter. The forward sections will be 8 feet long, and will have couplings forged on to match those of crank-shafts, to which they will be secured in the same manner as the other couplings of those shafts. The next section will be made with eleven collars finished 17 inches in diameter, and 1½ inch thick, with spaces 1½ inch between them. They will have couplings 29 inches in diameter and 5 inches thick forged on them for uniting with the other shafting. The forward section will be finished 14 inches in diameter for a length of 20 inches, and the section to be 14 inches in diameter for a length of 30 inches for the disengaging couplings. The two after sections of the shafts will be finished 13½ inches in diameter, the inboard section to have couplings to correspond with the others of the line-shafting, to which they will be united, each with five steel bolts 2¼ inches in diameter, and a steel cross-key 2 inches thick by 3 inches wide, recessed 1 inch in each coupling. The inboard shaft will be connected with a finished composition casing ⅝ inch thick, extending from 12 inches within the stuffing-boxes to 3 inches within the coupling for it and the propeller shafts. The length of the inboard sections will be approximately 32 feet 3½ inches, and of the outboard ones 39 feet 3½ inches. The propeller shafts will also be covered with a composition casing ⅝ inch thick, extending from 3 inches within the coupling to 3 inches within the hubs of the propellers; the ends for the propellers are to be tapered from the casing for a length of 30 inches, and reduced to a diameter of 11 inches; they will each be fitted with two steel feathers 1¾ by 1¾ inches, placed opposite each other; also a steel cross-key 2 inches thick by 5 inches wide; the two after sections

of each shaft will be united by a sleeve coupling of steel 21 inches in diameter and 42 inches long, secured by two steel feathers $1\frac{3}{4}$ by $1\frac{3}{4}$ inches, placed opposite each other, and also by two cross-keys 2 inches thick and 5 inches wide; the sleeve couplings will be bored $14\frac{1}{2}$ inches in diameter, slightly tapering, and the shafts turned to accurately fit them.

PROPELLERS.

The propellers are to be made of steel, to have a diameter of 15 feet 6 inches, or greater if required, a pitch of 22 feet 6 inches, and a length of — inches; they are to have four adjustable blades, or to be of such design as may be approved to obtain the best results. The edges to be made sharp, and surfaces of the blades to have all roughness smoothed off. Each hub will be — inches in greatest diameter, and will be — inches in length. At forward end it is to be counterbored—inches in diameter for a length of 3 inches, to receive bushing of shaft, aft of which the bore will suit taper of shaft. There is to be a cap $1\frac{1}{2}$ inch thick fitted at after end, with a central boss 1 inch thick recessed into the bore of hub.

HANGERS.

The bearings in outboard hangers for each propeller shaft to be fitted with lignumvitæ bearings in composition bushings, in the same manner as the stern-pipe bearings, as shown on drawings; the length of the bearings is to be 4 feet 6 inches; the diameter of each is to be $14\frac{3}{4}$ inches, and the width of hangers 3 feet 7 inches.

STERN-PIPES.

The stern-pipes will be made of cast iron $1\frac{3}{4}$ inch thick for the lengths of the bushings, and $1\frac{1}{2}$ inch thick between them, and well ribbed on the outside; the outboard end will be turned to fit the water-tight bulkhead and the outer skin, and be secured to it with wrought-iron bolts, passing through them and through lugs on the pipe; the inboard end will be made with a flange 5 inches wide and $2\frac{1}{4}$ inches

thick, by which it is to be secured to the after bulkhead by bolts 1¼ inch in diameter. The pipes will be bored 19 inches in diameter for a length of 33 inches at each end for the bushings.

The shafting outside of the stern-pipes will be inclosed and protected by casings of suitable material, which will be fixed to the stern bearings and hangers.

STUFFING-BOXES.

The stuffing-boxes will be made of composition, and will each have a packing space of 1 inch by 14 inches deep, and fitted with a follower made in two parts, with a space of 1½ inch between them, each part to be adjusted by three bolts 1¼ inch in diameter; the chamber of the stuffing-box to have a nozzle for connecting a valve of 3 inches diameter.

Where the shafts pass through the water-tight bulkheads of after engine-rooms they will be fitted with stuffing-boxes with composition followers and bushings.

DISENGAGING-COUPLINGS.

The disks for the disengaging-couplings are to be of cast iron, each made with four lugs projecting 4½ inches; the radial faces of the lugs of one disk to have steel plates 12 inches long fixed to them; the lugs of the other disks to be fitted in the same manner with composition plates, the hubs of the disks to be turned 24 inches in diameter and bored to fit the shafts; the depth through the eye of the couplings to be 20 inches; the disks for the fixed couplings of each shaft to be faced 6 inches wide and turned to a diameter of 56 inches, and to have a wrought-iron worm-gear shrunk on and keyed to the circumference for meshing with a turning-engine; the sliding disks will also have holes 3 inches in diameter and about 6 inches apart fitted with four steel pins, 6 inches long, for jacking the engines; the sliding disks are each to be turned to a diameter of 56 inches and 9 inches wide, and to have a wrought-iron band 1 inch thick and 9 inches wide shrunk on the circumference, the hub to have a band 3 inches wide and 2 inches

thick, accurately fitted and shrunk on; each sliding clutch will have a circular groove 5 inches wide and 2¾ inches deep for a collar, which will be coupled to a forked lever fitted with a screw and hand-wheel for engaging and disengaging the couplings. The couplings will be keyed to shaft by two steel feathers 2 inches by 2 inches and 30 inches long, placed opposite each other.

FRICTION-BAND.

A spring-steel band 5 inches wide and not less than § inch thick will be bored to fit the circumference of each fixed disk and fitted with a screw, hand-wheel, and connections for clamping the disk and securing it in any position.

PROVISIONS AGAINST TOTAL DISABLEMENT.

The following spare pipes will be furnished of copper: Two connected with the main stop-valves, so that in case of the irreparable disabling of the high-pressure engine, the steam may be conducted directly from the boilers to the low pressure cylinders; other pipes so arranged that in case of the total failure of either low-pressure engine the exhaust steam may be carried from the high-pressure cylinder directly to the condenser, and the flanges, bolt-holes, &c., by which these lengths are to be connected are to be so fitted that the pipes may be used on either engine, according to the one in which the casualty occurs; other pipes are to be arranged for conducting the exhaust of either low-pressure cylinder to the atmosphere through a hatch or ventilator in case of the break down of one of the condensers.

BOILERS AND ATTACHMENTS.

There are to be fourteen horizontal return-tubular boilers, placed forward of the engines, seven on each side of the vessel, with two fire-rooms running fore and aft between them, the forward containing six and the after one eight boilers. The boiler-compartments are to be water-tight and

separate. The fire-rooms are to be 11 feet wide, excepting between the two forward boilers, which are placed at an angle with each other. There are to be two smoke-pipes in vertical line over the keel, each connecting with an uptake common to all the boilers of each compartment. The boilers are to be constructed of steel, which must conform to the "tests of steel for boilers of steel cruisers," prescribed by the Naval Advisory Board, and approved by the Secretary of the Navy, June 10, 1883; the same being annexed and forming part of these specifications; the sheets are to be as large as practicable. All seams not in contact with the fire to be double-riveted; all the plates to be planed on the edges; the seams, except where otherwise specified, to be butt-jointed and covered with straps of the same thickness as the plates with which they are in contact; all to be calked perfectly tight.

Each boiler is to be 9 feet in external diameter, 9 feet 10 inches in length on bottom, and set inclining downwards from front to back, over a single furnace below the shell, being supported by girder-beams of boiler-plate, lined internally with fire-brick. The distance from floor of ship to top of boiler is to be 13 feet 6 inches.

GRATE SURFACE.

Each furnace is to have a grate about $92\frac{1}{4}$ inches wide and $89\frac{1}{2}$ inches long, making $57\frac{1}{3}$ square feet, and aggregating 802 square feet in the fourteen boilers.

GRATE-BARS.

Grate-bars to be double, in two lengths, $\frac{3}{4}$ inch thick at top, $\frac{5}{16}$ inch at bottom, about $3\frac{1}{2}$ inches deep at centers, and 2 inches at ends.

TUBES.

Each boiler is to contain two hundred and ninety-nine lap-welded iron tubes, $2\frac{1}{2}$ inches in external diameter, 7 feet $\frac{1}{2}$ inch long.

SHELLS.

The shells are to be formed of plates $\frac{5}{8}$ inch thick; longitudinal joints to be butted and double-strapped, circumferential joints to be lapped, and all to be double-riveted except in fire-surfaces.

HEADS.

The front heads are to be $\frac{3}{4}$ inch thick, the back heads to have the upper sheet $\frac{5}{8}$ inch and the lower one $\frac{9}{16}$ inch thick; each head composed of two plates, making one horizontal joint, planed and butted; the straps to be $\frac{5}{8}$ inch thick and 9 inches wide, double-riveted on each side of seam. The heads will be braced by rods $1\frac{7}{8}$ inch in diameter, placed 12 inches between centers, the ends of rods to be made with jaws and coupled to stay-plates at each end by a wrought-iron bolt $1\frac{3}{4}$ inch in diameter. Stay-plates to be of the best steel, $\frac{3}{4}$ inch thick, and secured to boiler by two angle-irons $2\frac{1}{2}$ by $2\frac{1}{2}$ inches. The stay-plates to be made with lugs 7 inches in diameter, leaving openings for the removal of the braces.

FURNACES.

The furnaces are to be rectangular, and lined with fire brick, varying in thickness from the grate to the junction of the walls with the boiler, as may be shown on the drawings to be approved.

BACK-CONNECTIONS.

The back-connections will vary in depth from 21 inches to $18\frac{1}{2}$ inches, and are to be made as shown in the drawings to be approved; the back plate to be of $\frac{9}{16}$-inch iron and to be stayed to the back head plate by screw stay-bolts, spaced not over 7 inches between centers horizontally, and $6\frac{1}{2}$ inches vertically; stay-bolts to be $1\frac{1}{8}$ inch in diameter excepting around the water-connection at bottom, where they are $1\frac{3}{8}$ inch. The sides of the back-connection are lined with fire-brick, but are to be formed externally of wrought-iron plates, which are the continua-

tion athwartships of the girder-plates which form the sides of the furnaces, but extending above those plates to a sufficient height to form the back-connection, and riveted to the boiler proper and the back water-connection. The latter is to be joined to the boiler at the bottom by a conical tube $\frac{3}{8}$ inch thick and having a mean diameter of $16\frac{1}{2}$ inches, and the back sheet of the water-space will be dished opposite this tube, to a depth of 3 inches. Additional tubes of smaller diameter to be put in if required.

TUBE-SHEETS.

The front tube-sheet is to be $\frac{3}{4}$ inch, the back one $\frac{5}{8}$ inch thick. They are to be accurately drilled for two hundred and ninety-nine tubes, spaced horizontally $3\frac{5}{8}$ inches and vertically $3\frac{1}{2}$ inches between centers. The segments of tube-sheets below the tubes are to be stayed by two braces $2\frac{1}{8}$ inches in diameter.

MAN-HOLES.

There is to be a man-hole 12 inches by 15 inches in the front head of each boiler below the tubes, and another of the same size in the shell. Each man-hole to have around it on the outside a wrought-iron band $1\frac{1}{4}$ inch thick and 5 inches wide, double-riveted to shell; inner row of rivets countersunk flush on both sides. Man-holes to be closed with dished wrought-iron plates and secured with double wrought-iron cross-bars and bolts.

FRONT CONNECTIONS AND UPTAKES.

The front connections and the uptakes are to be made with double shells of wrought iron, built on frames of channel iron $2\frac{1}{2}$ inches by $1\frac{1}{2}$ inch; the inside and outside shells to be made of iron weighing, respectively, 5 pounds and $3\frac{8}{16}$ pounds per square foot; the space between shells to be filled with non-conducting material. The forward uptake at its connection with the smoke-pipe to be 11 feet 5 inches in diameter, and the after one 12 feet. The doors

are to be made of wrought iron with double shell, and fitted with the proper hinges and catches, both shells ¼ inch thick, the outer one flanged 1 inch deep, the inner one 2¼ inches deep.

FURNACE-FRONTS.

The furnace-fronts are to be made with wrought-iron frame lined with fire-brick, and having two openings 24 by 15 inches for furnace-doors. The outer plates of doors to be of wrought-iron ¼ inch thick, flanged 1 inch deep, and to have air-slits ⅝ inch wide; the inner plates to be perforated with ¼-inch holes of the same aggregate area; doors to have the necessary hinges, latches, and catches of wrought iron. Each front is also to be provided with two registers for admitting air to the gases, and small doors through which to slice the fires. The ash-pit doors are to be well fitted to close the ash-pits air-tight when the blast is introduced at the back end, and arranged to hang by proper hooks to up-take doors when not in use.

SADDLES.

Each boiler is to rest on two girder-beams formed of wrought-iron plates ⅜ inch thick, 6 feet long, and 4 feet 4½ inches in mean depth, secured to keelsons by angle-irons, and carrying light floor-plates on top for giving access between certain of the boilers. The girder-beams are to be strengthened by at least three webs, inside and out, built up of boiler-plate and angle-irons. The boilers are to be secured to the beams by angle-irons and bolts, the latter to be snugly fitted in reamed holes.

SMOKE-PIPES.

The smoke-pipe for the forward group of boilers is to be 11 feet in diameter inside, and for the after group 11 feet 6 inches; the total height to be not less than 60 feet above the grate. The lower lengths to be of No. 7 and the upper ones of No. 8 iron, Birmingham gauge. The pipes are to be made with the proper bands, butt-straps, eyes, stays, and supports for covers. There is to be an air-casing around

the base of each smoke-pipe, of square section until it passes through the deck, after which it will surround the smoke-pipe and will be 3 inches wide.

STEAM-DRUMS.

There is to be a steam-drum in each smoke-pipe, concentric with it and 9 feet in diameter, 9 feet long, $\frac{7}{8}$ inch thick in shell, and $\frac{11}{16}$ inch thick in the heads; it is to have eight 18-inch and four 15-inch lap-welded flues passing lengthwise through it; the heads are to be braced with eight rods $1\frac{1}{8}$ inch in diameter, and to have a man-hole 12 by 15 inches in each, with the usual plate, cross-bars, and bolts. There will be a connection on the forward and after side of each drum about one-third of its length from the bottom, for the admission and withdrawal of steam when the drum is in use, the pipe for the latter purpose extending upward internally.

SUPERHEATING PIPES.

Superheating steam-pipes, 12 inches in diameter for the forward group of boilers and 15 inches for the after one, made of copper, No. 3 and No. 1 Birmingham gauge thick, respectively, are to pass through the front connections on each side. They will be connected by branch-pipes to the drums so that the steam from the forward boilers may be admitted to the forward drum, and the steam from the after boilers to the after drum; they will also be connected to the main steam-pipes, 15 inches in diameter, passing through the fire-rooms, so that the steam may flow directly to the engine without passing through the drums. The branch-pipes connecting the superheating pipes with the boilers are also to be of copper, and the sections united by composition flanges.

SAFETY-VALVES.

Each boiler and superheating pipe is to have an automatic spring safety-valve $5\frac{1}{2}$ inches in diameter, adjusted to a pressure of 100 pounds of steam, and fitted with the proper levers. The chests, valves and stems to be of composition and seats of nickel. There are to be three escape-

pipes of copper, alongside the smoke-pipes, and each safety-valve chest will be connected with the nearest of these by a branch-pipe, also of copper. Separate provision is to be made for raising the safety-valves from the adjoining compartment or from the deck if necessary.

DRY-PIPES.

Each boiler is to have a properly perforated wrought-iron dry-pipe, thoroughly tinned, and of an internal diameter of 6½ inches; the pipe is to be placed as high as possible and to extend nearly the length of the boiler; the aggregate area of the perforations to be double the cross-section of the pipe.

BOILER STOP-VALVES.

Each boiler is to have a composition stop-valve chamber combined with the safety-valve chamber, placed on the shell near the top, and united with the boiler and dry-pipe by flanges of suitable size and thickness; the chest to be not less than ⅜ inch thick. The valve to be 6 inches in diameter, and fitted with a composition screw-stem, made to turn independently of the valve and to work in a composition nut supported by wrought-iron studs on the cover. The valve is to be operated by a composition hand-wheel 12 inches in diameter; separate provision is also to be made for closing the stop-valves from the adjoining compartment or from the deck if necessary. The stop-valve chambers are to be connected with the superheating-pipes by copper branch-pipes, 6 inches in diameter where single, and 8½ inches where coupled in pairs; the pipes to have composition flanges of suitable diameter and thickness, properly riveted and brazed on.

INTERMEDIATE STOP-VALVES.

There are to be two stop-valves in the forward fire-room to pass the steam from that group to its steam-drum, shutting off the starboard or port boilers if desired; two more valves at the after end of forward fire-room to admit steam directly from that group to the engines without passing it

through the steam-drum, also shutting off starboard or port side; there is also to be one stop-valve on the steam-pipe from forward boiler, but placed in the after fire-room, to shut off steam from the forward group.

There are to be two stop-valves in after fire-room, to pass the steam from the after group through its steam-drum, shutting off the starboard or port boilers, if required; two more valves at after end of after fire-room to admit steam from that group to either starboard or port engine after it has passed through the steam drum; and finally, two more stop-valves to admit steam from either starboard or port after-boilers direct, or from forward group alone, to either starboard or port engine.

The chests of these valves are to be of cast iron, and, with the flanges, to be of ample thickness; they are to be fitted with composition valves, seats, and stems; the former to be about 12, 13, and 15 inches in diameter, respectively, for the forward group of boilers, and 15 inches for the after group. The stems are to turn independently of the valves, and to work in composition nuts supported by wrought-iron studs on the covers; the valves to be operated by composition hand-wheels from 17 to 23 inches in diameter.

HAND-WHEEL RIMS.

The rims of hand-wheels of all large steam stop-valves are to be inclosed in asbestos covered with stitched canvas.

STEAM-PIPES.

The main steam-pipes leading to engines are to be of copper 17 inches in diameter and of No. 2 Birmingham gauge thickness, connected with the high-pressure cylinder by means of a stop and throttle-valve; the several sections to be united to each other and the valve-chambers by composition flanges of ample thickness, properly riveted and brazed to the pipes. All the steam-pipes, large and small, are to be heavily tinned inside and out.

MAIN ENGINE STOP-VALVES.

The stop-valve chambers are to be of cast iron; the seats, valves, and stuffing-boxes of composition. The valves are to be 13 inches in diameter. The stems and hand-wheels are to be of composition, the latter about 18 inches in diameter.

THROTTLE-VALVES.

Each throttle-valve and chamber is to be of composition, the valve to be balanced and to have an area equal to that of the stop-valve; to be connected by proper rods and levers to be operated from the working platform.

SMALL STOP-VALVES.

Four of the boilers at least shall be fitted with suitable stop-valves and pipes for supplying the pumps, heaters, and all small engines with steam, and there shall also be a branch for the same purpose leading from the main steam-pipe, and a pipe will unite the connections from the wing-boilers on each side for the same purpose. Two of the boilers in the forward fire-room shall also be connected with the distilling apparatus to supply it with steam.

STEAM-RELIEF.

There is to be a copper pipe, with stop-valve 6 inches in diameter, leading from the steam-pipe to each condenser for steam-relief.

FEED-VALVE.

Each boiler is to have a check feed-valve 2½ inches in diameter, inclosed in a chest having two stop-valves of the same diameter, which may be closed, the one from the boiler and the other from the feed-pipe; the valves and chest to be of brass, and made with flanges of proper diameter and thickness for connecting with feed-pipes and boiler.

SALINOMETER POTS.

There are to be fourteen salinometer pots of such pattern as may be selected, fitted in such a manner as to be easily accessible.

WHISTLE.

A large finished steam whistle of brass is to be conveniently placed above deck and on forward side of forward smoke-pipe, with copper pipe and cock connecting to main steam-pipe of each set of boilers.

TEST.

Before being placed in the vessel all the boilers are to be tight under a pressure of 150 pounds to the square inch, which is to be obtained by filling the boilers quite full of water and lighting a fire in the furnaces, producing the pressure by the expansion of the water. The boilers, after completion, are to be painted outside with two coats of brown zinc paint.

FELTING.

After the boilers are in the vessel the shells and backs of the same are to be inclosed within an air-space. The covering to be made of galvanized iron, with suitable openings over man-holes.

VENTILATORS.

Eight ventilators, six of 24 inches and two of 16 diameter, are to be fitted, four in each compartment; they are to extend below the deck to within 8 feet of the fire-room floor, and be bell-mouthed at the lower end. They are to have movable hoods, capable of being worked from the fire-room by gear made of composition. The ventilators will be made of iron $\frac{3}{16}$ inch thick above deck, except the lower section, which will be $\frac{1}{4}$ inch thick; the portion below deck will be No. 11 wire-gauge thick. The forward pair in each fire-room will be arranged for hoisting ashes through them to the deck by means of the ash-hoisting engine, or by

blocks and pulleys; they are to be strengthened with six strips of bar-iron placed vertically in the interior; to have a side door for passing the ash-buckets through, and all the ventilators to admit of being closed tight when the blowers are in operation. [Provided for in hull specifications.]

ASH-HOISTING ENGINES.

Two ash-hoisting engines of suitable dimensions and sufficient power will be furnished, one at the forward end of each fire-room.

STORE AND OIL ROOMS.

The store and tool-room is to be on the port side, the oil-room is to be placed as shown on the drawings, and the former are to be suitably fitted with shelves, lockers, doors, &c., and well painted. The waste-locker is to be fitted with a water-pipe for flooding.

FLOOR-PLATES.

The fire-rooms, engine-rooms, and their passages are to be floored with plates having corrugations and proper ledges and drain-holes; plates to be made of wrought iron, if obtainable, and all easily removed.

BLOWERS.

There are to be two blowers of such type as may be approved, in each fire-room; drawing the air from outside through ducts provided for them, and discharging it through pipes either into the air tight boiler compartments or into the outboard fore and aft boiler-keelsons, which form air-ducts, whence it is to be distributed to the ash-pits through openings adjustable from the fire-rooms; the starboard and port systems to be separate. Each blower is to be driven by a single-cylinder engine coupled directly with it. The fans of the after blowers are to be 60 inches, and of the forward ones 54 inches in diameter. The former are to deliver

20,000 cubic feet, and the latter 15,000 cubic feet each, maintaining a pressure due to a column of at least 1½ inch of water in the air ducts.

AIR-TIGHT COMPARTMENTS.

The boiler compartments are to be made sufficiently air-tight to maintain all the pressure which these blowers can furnish.

MISCELLANEOUS ARTICLES, MATERIALS, ETC.

OIL-CUPS.

The crank-shaft journals are each to have three large finished brass oil-cups of approved design, with tubular wick-holders adjustable in oil-tubes. Each crank-pin journal and beam-center journal is to have two similarly fitted large finished brass automatic oil-cups of approved design, and each connecting-link to have one. All other engine-journals and moving parts, and especially the cross-head gibs, are to have finished brass oil-cups of suitable size. Each cylinder is to have two properly finished brass grease-cocks, with globe, upper cock, and cup, and each valve-chest to be fitted with an oil-pump. Where necessary, sheet-brass drip-pans are to be attached.

WATER-PIPES.

Water-pipes of copper, 3 inches in diameter, are to lead from the steam-pipe stuffing-box cocks to engine-rooms, and to be fitted with cocks and hose attachments for the thrust and line-shaft bearings; also, branch-pipes and cocks for all water-brasses. There will be pipes for supplying the crank-shaft journals, crank-pins, beam-centers, and cross-head guides. There are to be suitable hose-pipes with rose-sprinklers, properly attached to the sea-valves for wetting down ashes.

BRASS BOXES.

All journals and moving parts of iron are to run upon brass boxes.

HOLES THROUGH SHIP.

All holes through the ship are to be fitted water-tight, and covered by cocks or valves on the inside.

EYE-BOLTS.

Wrought-iron eye-bolts and traveler-bars are to be properly located and secured wherever required, for lifting different parts of machinery, and particularly the covers of cylinders and valve-chests, the covers of air and circulating-pumps and their valve-chests, the condenser-bonnets, and the caps of pillow-blocks of crank-shafts, beam-centers, and line-shaft journals.

PAINTING.

All engine work not finished is to be primed with two coats of brown zinc and oil; when placed in the vessel to be painted with two coats of chrome green and oil. The line-shafting is to be painted, after being placed in the vessel, with two coats of white lead and oil. After the boilers are in position the fronts are to be painted with two coats of lampblack and oil. The smoke-pipes are to be thoroughly painted before and after erection. All steam-pipes not cased will be painted white, exhaust-pipes green, and water-pipes leading from pumps lead-color; in doubtful positions the direction of flow to be marked by a painted arrow-head.

DRAWINGS.

A complete set of drawings in detail is to be furnished and facilities provided for the draughtsman assisting the Inspector.

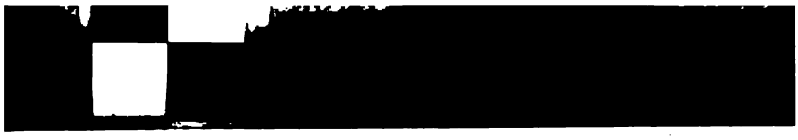
MATERIALS AND WORKMANSHIP.

All materials used in the construction of the machinery are to be of the best quality. All steel castings are to be of the best quality of material, combining ductility with the strength required. The iron castings to be made

of the best pig-iron, not scrap. The brass to be of pure copper and tin, from new materials; for all journal-boxes and guide-gibs, the composition to be by weight, six parts of copper, one part of tin, and one-fourth of one part zinc. For other brass work the composition to be eighty-eight parts of copper, ten parts of tin, and two parts of zinc. The iron castings to be smooth and true to form, and before being painted to be well cleansed of sand and scale. Brass castings to be smooth and true. No imperfect castings or unsound forgings to be used, whether the imperfection relates to strength or appearance. All steam, exhaust and other pipes leading to and from steering and other engines, blowers, compartment, distilling, and other pumps are to be of sufficient size, with provision for expansion where necessary. All copper pipes to be brazed, and to have brass flanges riveted on, calked on both sides and brazed. All pipes not otherwise specified, to be of copper and tinned inside and out. All nuts on rough castings to set on facings raised above the surface. The work to be in every respect of the first quality and executed in a workmanlike and substantial manner. All the flanges to be faced and grooved. No standing or other bolt-holes to be drilled through into vacuum spaces. All the bolt-holes to be reamed, and the body of the bolts to be finished to fit them snugly. All threads on bolts to correspond with the Navy standard. All brasses to fit loosely between collars of shafting. All cocks communicating with vacuum spaces to have bottom of shells cast in, and to have the plug packed by means of a stuffing-box and follower. All nuts on moving parts and on pillow-blocks to be thoroughly secured with keepers, pins, or steel set-screws. All brass boxes for journals to be properly channeled for the distribution of oil. All flanges coupled together to be faced, and edges made fair with each other. Packing of stuffing-boxes to be of approved kind.

PATENT FEES.

All patent fees to be paid by the builders, and no extra bills to be presented or additional compensation claimed.



Materials and parts of machinery to be carefully weighed, and the records, certified by the Inspector, to be sent from time to time to the Naval Advisory Board and to the Bureau of Steam Engineering.

DAMAGES RECOVERABLE.

If, after the completion of the machinery, there shall at any time be discovered in it any departure from the specifications, tending to cheapen its construction by lessening the thickness of metal, or by substituting iron for brass, or tool-finish for finish, or brass in which zinc is a large element, or by omisssion of finish when specified on drawings or when usual on naval vessels, or by lessening the diameters and areas of pipes, valves, &c., the injury to the Government thus received may be estimated and determined by the Naval Advisory Board under direction of the Secretary of the Navy, and the amount recovered from the parties of the first part, who hereby agree to abide by such determination.

DUPLICATE PIECES.

All duplicate pieces are to be finished, fitted to place, and ready for use. They are to be as follows:

Two sets of carbolized gum valves and springs fo steam-pumps.

One set of valves, with guards, bolts, &c., for receiving and delivery valves of air-pumps.

One set of valves, with guards, bolts, &c., for receiving and delivery valves of circulating-pumps.

One set of follower-bolts and nuts for each steam-piston, and one set for each air and circulating-pump steam-piston.

One set of brasses for each main journal of the crank-shafts.

One set of brasses for each beam-center journal.

One set of brasses for each connecting-link.

One set of brasses for each crank-pin.

One set of brasses for each connecting-rod pin.

One set of slippers for each cross-head guide.
One brass block for each Stephenson link.
One set of brasses for each eccentric-rod connection.
One set of brasses for each thrust-bearing.
One set of brasses for each line-shaft pillow-block.
Two crank-pin oil-cups, with all appendages.
Four beam-center oil-cups.
Three main journal oil-cups.
Two hundred tubes for condensers, packed in boxes.
One complete set of paper or kiln-dried wooden grommets, as may be approved, for tubes of one condenser, packed in tin, water-tight, and with cases marked.
Four Macomb bilge-strainers.
All duplicate pieces not of brass to be painted with three coats of white lead and oil, and well lashed in tarred canvas, with name marked on the outside. Brass pieces to be painted with one coat of white lead and oil, and plainly marked for what purpose intended.

OIL-TANKS, CANS, ETC.

Four oil-tanks of iron ¼ inch thick, with an aggregate capacity of 1,800 gallons, are to be well secured in oil storeroom, with facilities for filling from deck and emptying, and strengthened by internal stays or otherwise, each to have a man-hole; also a brass cock 1 inch in diameter placed in the bottom, suitably connected with a pump.
Two copper oil-tanks of 10 gallons capacity each, with lids and drip-pans, to be placed permanently in the engine-room, in a convenient position, and to have a locked brass cock on each.
One iron tallow-tank, of three hundred and fifty pounds capacity, with hinged man-hole plate on top.

INSTRUMENTS, TOOLS, ETC.

Six Tabor indicators of standard size are to be furnished, ready-fitted, three with springs graduated to a scale of 40 pounds to the inch, and three for a scale of 20 pounds to the

inch. Each indicator stand-pipe is to be connected with each end of its main cylinder by pipes 1½ inch in inside diameter, having cocks of equal area of openings.

One set of instruments, with proper attachments, to be supported, each in a brass case, as follows:

One Lane's improved spring steam-gauge.

One Lane's improved spring compound gauge.

One spring vacuum-gauge.

Faces of gauges to be 8½ inches in diameter.

One counter with positive motion.

One eight-day clock, to strike in accordance with ship's time, placed independently of the other instruments and so as to be unaffected by the vibrations of the machinery.

One mercurial steam-gauge, attached to main steam-pipe.

Two mercurial vacuum-gauges for condensers, attached immediately to them.

Two mercurial siphon-gauges, attached to the low-pressure valve-chests, with a glass tube to indicate pressure from six to forty pounds above perfect vacuum.

Fourteen Lane's improved spring steam-gauges, with 8½ inches face, in fire-room, so arranged that each boiler will have an independent connection with one gauge.

Seven thermometers; one for fresh-water reservoir and one for filter, one in each outboard delivery-pipe, one for each injection, and one for the steam-pipe; to be made permanent fixtures, with their stems and bulbs protected by brass covers.

Two engine-room annunciators, with pulls, dials, finished brass plates and attachments, arranged to be operated from any parts of the deck required.

A copper speaking-tube to lead from the engine-room to each fire-room, with small gongs attached.

Two complete sets of fire-irons.

Lazy bars for each boiler, fitted in place.

One set of wrenches complete, for engine, fitted to all the nuts, finished, marked with size, and placed in walnut racks. Wrenches for all nuts of bolts 2 inches in diameter and over to be box-wrenches, and placed in convenient racks.

Sixteen ash-buckets, painted with three coats of brown zinc and oil.

Sixteen coal-buckets, painted with three coats of brown zinc and oil.

Hose-couplings of naval standard, fitted for fire-hose and furnished with caps and spanners, are to be placed as permanent fixtures through water-tight bulkheads in such a manner that the doors in said bulkheads need not be opened for the passage of hose.

TESTS OF STEEL FOR CRUISERS.

INSTRUCTIONS TO INSPECTORS.

NAVY DEPARTMENT,
NAVAL ADVISORY BOARD,
June 18, 1883.

The following rules are prescribed in order to insure the fulfillment of the clause of the act of Congress of August 5th, 1882. "Such vessels * * * to be constructed of steel, of domestic manufacture, having as near as may be, a tensile strength of not less than sixty thousand pounds to the square inch, and a ductility in eight inches of not less than twenty-five per centum:"

I. All ship-plates, beams, angles, rivets, bolts, boiler-plates, and stays to be inspected and tested at the place of manufacture by a Naval Inspector of Material, and to be passed by him, subject to restrictions hereinafter mentioned, before acceptance by the ship-builders, whether Government or private, for incorporation into said vessels.

II. Every plate, beam, and angle, supplied for these vessels, to be clearly and indelibly stamped in two places, and with two separate brands: 1st. With that of the maker, which shall distinguish the name of the manufactory or company. 2d. With the regulation brand of the Naval Inspector of Material. The latter not to be stamped upon any of the above-mentioned material until it shall have passed the required inspection and tests, have been accepted by the Inspector, and have been stamped with the maker's brand.

In case of small articles passed in bulk, the above-mentioned brands shall be applied to the boxing or packing material of the objects.

No steel material to be received at the building yards for incorporation into the vessels except it bear, either upon its surface or that of its packing, both of these brands as evidence that it has passed the necessary Government inspection.

SHIP-PLATES.

III. In every lot of 20 plates test pieces to be cut from two plates taken at random; two test pieces being cut from each plate, one in the direction of the rolling, and one at right angles to it, shaped according to the annexed sketch. These test pieces shall in no case be annealed.

The test pieces to be submitted to a direct tensile stress until they break, and in a machine of approved character.

The initial stress to be as near the elastic limit as possible; which limit is to be carefully determined by the Inspector in a special series of tests. The first load to be kept in continuous action for five minutes. Additional loads to be then added at intervals of time as nearly as possible equal, and separated by half a minute; the loads to produce a strain of 5,000 pounds per square inch of original section of the test piece until the stress is about 50,000 pounds per square inch of original section, when the additional loads should be in increments not exceeding 1,000 pounds.

An observation to be made of the corresponding elongation measured upon the original length of eight inches.

The final elongation to be that obtained at rupture. The loads applied shall never be calculated from the indications of the pressure gauge if a hydraulic press be used.

CONDITIONS OF ACCEPTANCE.

In order to be accepted the average of the four test pieces must show an ultimate tensile strength of at least 60,000 pounds per square inch of original section, and a final elongation in eight inches of not less than 23 per cent.

Lots of material which show a strength greater than 60,000 pounds per square inch will be accepted, provided the ductility remains at least 23 per cent.

CASES OF FAILURE.

If the average of these four test pieces, numbered 1, 2, 3, 4 (called Test I), falls below either of the required limits, the plates from which pieces 1, 2, 3, 4 were cut shall be reected, and Test II made, consisting of pieces 5 and 6, cut from a third plate; if the mean of the results of these two falls below either of the above limits, the entire lot shall be rejected. If it be successful, Test III, or the mean of pieces 7 and 8, cut from a fourth plate, shall decide.

If in any of Tests I, II, III, any single piece shows a tensile strength less than 58,000 pounds, or a final elongation less than 21 per cent., the plate from which it was cut shall be rejected, and that test considered to have failed regardless of its average.

QUENCHING TEST.

IV. A test piece shall be cut from *each* plate, angle, or beam, and after heating to a cherry red plunged in water at a temperature of 82° Fahrenheit. Thus prepared it must be possible to bend the pieces under a press or hammer so that they shall be doubled round a curve of which the diameter is not more than one and a half times the thickness of the plates tested, without presenting any trace of cracking.

These test pieces must not have their sheared sides rounded off, the only treatment permitted being taking off the sharpness of the edges with a fine file.

ANGLES, BEAMS, BULB BARS, T-BARS, ETC.

V. In every lot of 20 angles or beams, &c., test pieces to be cut from the webs of two taken at random, one from each. These pieces to be fashioned in the same way, and to be subjected to the same tests, both tensile and quenching, and to fulfill the same requirements for acceptance as already prescribed for ship-plates.

Angle bars are to be subjected to the following additional tests: A piece cut from one bar in twenty to be opened out flat while cold under the hammer; a piece cut from another bar in the same lot shall be closed until the two sides touch, while cold; a piece from a third bar of the lot to be bent cold into a ring so that one of the sides of the angle bar shall be kept flat and the other side forming a cylinder, of which the internal diameter shall be equal to 3½ times the breadth of the side which remains flat. The angle bars submitted to these tests must show neither cracks, clifts, nor flaws.

Single T-bars to be submitted to the following tests: A piece to be cut from the end of a bar taken at random from each lot of 20, and to be bent cold into a half ring, so that the web remaining in its own plane, the cross flanges shall form a half cylinder, of which the internal diameter shall equal four times the height of the web of the T-bar.

At the end of another bar of the same lot the web to be split down its middle for a length equal three times its total depth, and a hole drilled at the end of the slit to prevent it spreading; the piece thus split to be opened out in its own plane, so as to make an angle of 45° with the rest, care to be taken that the part opened shall be kept straight, except that it must be joined to the rest of the bar by a bend of small radius.

Bulb bars are to be subjected to the same tests as those prescribed for T-bars, except that in bending one or more heats may be used.

All bars submitted to these tests must show neither cracks, clifts, nor flaws.

RIVETS.

VI. One bar from every lot of 20 of the bars from which rivets are made shall be subject to the same tensile test as that required for the plate tests. All bars not fulfilling the requirements of tensile strength and elongation required for plates to be rejected.

From every lot of 500 pounds four rivets are to be taken at random and submitted to the following tests, one rivet to be used for each test: 1st. A rivet to be flattened out cold under the hammer to a thickness of one-half its diameter without showing cracks or flaws. 2d. A rivet to be flattened out hot under the hammer to a thickness one-third its diameter without showing cracks or flaws. 3d. A rivet to be bent cold into the form of a hook with parallel sides without showing cracks or flaws. 4th. A rivet to be tested by shearing by riveting it up to two pieces of steel which are to be submitted to a tensile strain, the rivet not to shear under a stress of less than 50,000 pounds per square inch.

BOILER-PLATES.

VII. *Each* boiler-plate must be subjected to the same tests and in the manner prescribed for ship-plates. The ductility in eight inches must not be less than twenty-five per cent., and the ultimate tensile strength must not be less than 57,000 pounds and not more than 63,000 pounds, and the average at least 60,000 pounds.

The acceptance of material under these tests will not relieve the contractor from the necessity of making good any material which fails in working or may be rejected by the Inspector.

R. W. SHUFELDT,
Rear-Admiral, U. S. Navy,
President Naval Advisory Board.

Approved:

WILLIAM E. CHANDLER,
Secretary of the Navy.